CHAPTER I

INTRODUCTION

1. Introduction

Every country now strives to showcase its excellence in all fields, and sports performance has become a globally recognized benchmark of success. Developed and developing nations alike invest significant resources in achieving sporting excellence, aiming to compete at the highest levels. Popular sports such as track and field, football, cricket, basketball, tennis, and badminton are widely played worldwide. As the competition intensifies, the demands of these sports continue to grow, leading to continuous advancements in training methods, performance analysis, and sports technology. In this evolution, research is essential to help the refinement of teaching methodologies, the development of innovative equipment, and the integration of new technologies to enhance athletic performance. The successful international sporting is the consequence of well-structured sports policies, investment in athlete development programs, and scientific advancements in training (**De Bosscher et al. (2008)**). Similarly, **Bangsbo et al. (2014)** highlight that improvements in training intensity, physical preparation, and metabolic conditioning have significantly influenced elite sports performance. Additionally, **Reilly et al. (2009)** emphasize the importance of an integrated strategy, involving physiology, psychology, and biomechanics to optimize talent development. Furthermore, **Fletcher & Arnold (2011)** discuss how leadership and management in elite sports have evolved to support athletes in achieving peak performance. Collectively, these research contributions directly or indirectly enhance the ability of individual athletes and teams to reach their optimal performance levels in the ever-competitive world of sports.

The ancient Greek philosopher Aristotle conveyed the value of individuals, as quoted by **Bucher (1968)**: The body serves as the sanctuary of the soul, and achieving a balance between body, mind, and spirit necessitates physical fitness. Numerous factors influence the effectiveness of the human body. Although the value of competent training has long been recognized, the relevance of providing thorough sports training has increased as sports have become more popular in society. **Bucher (1968)** asserts that sports training and physical education are essential for improving mental and emotional health in addition to physical prowess. The integration of scientific principles into training

programs has led to improved performance and injury prevention, reinforcing the idea that well-structured training is essential for athletic success.

More than three millennia ago, the Greeks recognized the necessity of delivering effective and efficient training for athletes participating in the Olympic Games. They understood that structured training was essential for maximizing athletic performance and sustaining competitive excellence. However, since the 1950s, numerous countries have acknowledged the significance of implementing scientifically designed sports training programs across various activities. According to **Bompa (1999)**, the development of periodized training techniques has been essential for improving sports performance and lowering injury risk. These structured training programs are essential for achieving success in major international competitions while also fostering physically and mentally healthy participants. As **De Bosscher et al. (2008)** highlight, nations that invest in long-term athlete development programs and systematic training strategies tend to produce elite-level competitors. Therefore, comprehensive sports training remains a critical factor in developing skilled, high-performance athletes capable of excelling in competitive sports.

1.1 Training

The word **training** generally refers to a variety of structured education intended to quickly improve a person's mechanical, mental, physical, or cognitive abilities. In the context of athletic endeavors, training is specifically the method of getting athletes ready for optimal performance, which includes the methodical growth of their physical and mental capacities as well as their drive to succeed. Sports training are a scientifically organized procedure that combines skill development, psychological preparation, and physical fitness to maximize performance, according to **Matveyev (1981)**. This concept of training has ancient origins, as evidenced by the rigorous preparation methods employed in early Olympic Games and military training, signifying a structured approach to preparing for tasks that may span days, months, or even years. As **Bompa (1999)** emphasizes, periodization and progressive overload are key principles in modern training programs, ensuring athletes gradually enhance their performance while preventing overtraining and injuries. Thus, training remains an essential component in achieving athletic excellence across various sports disciplines.

However, there exists some variation in the interpretation of the term training within the sports community. For example, some professionals, especially in the field of sports medicine, consider sports training to be essentially physical activity. This viewpoint is reflected in important phrases like strength, interval and technical & tactical training. Examining the training of professional players, however, reveals the intricacy of sports training. Numerous sports science fields, including sports medicine, nutrition, sports physiology, physiotherapy, sports biomechanics and sports psychology, are heavily incorporated into the training of elite athletes. The importance of cooperation between coaches and sports scientists is highlighted by this synergy between coaching and sports science, not the role of the coach. In the end, the coach is still in charge of organizing, carrying out, and overseeing training.

1.2 Sports Training

Sports training means a purposeful and goal-oriented human activity aimed at studying its effects on sports performance and utilizing this knowledge to enhance athlete preparation for competitions. It encompasses various methods beyond physical exercises, serving as a fundamental aspect of athlete preparation. Sports training is a methodically organized and regulated procedure with scientific knowledge and is essential for enhancing performance (**Matveyev, 1981**). Additionally, it plays a vital didactical role in coaching and player development, helping athletes acquire essential skills and tactical awareness (**Bompa, 1999**). Not limited to performance sports, training extends its significance to diverse domains, contributing to fitness and health development. According to **Bosscher et al. (2008)**, structured sports training programs are essential for fostering athletic excellence at both elite and grassroots levels. Athlete development within training involves a diverse array of methods, primarily through the application of physical loads via exercises, with coaches responsible for selecting suitable training methods for optimal performance enhancement. In its broadest sense, training refers to organized instructional processes aimed at enhancing physical, psychological, and intellectual abilities (**Haff& Triplett, 2015**).

In the realm of sports, this process entails preparing athletes to achieve peak performance levels through regular and systematic exercise routines. However, the efficacy of these exercises depends on various factors such as training load, recovery methods, performance assessment, sports equipment, nutrition, psychological factors, and

instructional methodologies (**Issurin, 2010**). Neglecting these factors diminishes the benefits of physical exercise, hindering athletes from realizing their full potential. Therefore, a well-structured and scientifically designed training program remains essential for maximizing sports performance while ensuring athlete longevity and overall well-being.

Purpose of Sports Training Programme

The purpose of sports training programs encompasses optimizing athletic performance, improving physical fitness, preventing injuries, and fostering overall well-being. These programs are tailored to individual sports, athletes, and their positions, incorporating structured exercises and drills to develop strength, speed, agility, endurance, flexibility, and coordination. Mental conditioning is integrated to enhance concentration, resilience, strategic thinking, and sportsmanship. Additionally, injury prevention techniques target muscle strength, joint stability, and biomechanical imbalances. Understanding and addressing various types of fatigue, including mechanical, metabolic, neurological, and psychological, are crucial for performance enhancement. Recovery strategies such as rest, regeneration, and active rest play vital roles in ensuring athletes perform at their peak.

1.3 Football

Football, a sport with a long history that began in middle of nineteenth century in England, has evolved over time. Its popularity transcends boundaries, playing a significant role in local communities, individual fan bases, and national identities worldwide. The FIFA World Cup, held every four years, stands as the pinnacle of football competition. Football demands a blend of tactical, technical, physical, physiological, and decision-making skills. The sport's complexity necessitates rigorous training methods focusing on endurance, strength, and speed. Over the past decades, the surge in football's popularity has paralleled increased research across various sports science disciplines. Football requires a diverse range of physical abilities, including running, sprinting, jumping, changing direction, and recovering from impacts. Success in football is influenced by factors such as anthropometry, physiology, technique, and perception, with specific skills like tackling, heading, Passing, Kicking, Dribbling, Shooting and maintaining defensive positions being paramount.

Football an intricate sport that necessitates a combination of high skills and optimum physical capabilities, such as accelerating, decelerating, jumping, changing direction, or executing a variety of broad actions in one or more attitudes, typically at maximum intensity (Smpokos et al., 2019). Over the past two decades, the pervasiveness of the sport of football has led to an equivalent rise in the volume of research carried out across the board in the many subfields of sports science (reilly & Gilbourne, 2003), this sport demands a wide range of physical abilities, including running and sprinting, accelerating and decelerating, jumping, changing direction, and recovering from falls and knocks. As a strategic game, football has its own set of rules and techniques for kicking a goal. Football players' effectiveness is impacted by high intensity interval and aerobic training on skill performance, physiological and physical elements. A few soccer-specific skills, such as tackling, heading, shooting, passing, trapping, and maintaining body posture when under defensive pressure, require physical exertion.

Football necessitates a unique combination of technical, tactical and physiological abilities. As a result, it‘s critical to cultivate and maintain this skill set. Athletes‘ physiological assessments can be used to examine or test their adaptation to different types of exercises and training given the prominence of high aerobic performance in football, as well as the limited time available to hone crucial physiological, tactical, and skill assessments, time-efficient and effective training techniques must be investigated.

1.4 High Intensity Interval Training

High-intensity interval training (HIIT), which increases aerobic and anaerobic fitness, is very beneficial for football players. In sports like football, where repeated sprints and quick bursts of effort are essential, incorporating HIIT into training routines can lead to noticeable enhancements in stamina, speed, and recovery. The method helps athletes perform better under physical stress by increasing their endurance and power output during matches. Historically, in the 1970s, Arthur Jones, the creator of Nautilus exercise machines, advocated for a high-intensity approach in resistance training. His philosophy emphasized performing weightlifting repetitions until the muscles involved reached the point of temporary fatigue. This strategy aimed to stimulate maximum muscle fibre recruitment by focusing on three core elements: the number of repetitions, the amount of resistance used, and the total time the muscle remains under tension (**Philbin and John, 2004**). Such a training model prioritized intensity over volume to optimize strength development.

HIIT follows a simple yet effective structure: short, intense periods of anaerobic effort alternate with brief recovery phases. This cycle repeats until the participant reaches physical fatigue. During each high-effort phase, athletes perform at a vigorous or near-maximum level, followed by rest or low-intensity movement. The alternating nature of HIIT challenges both energy systems, improving cardiovascular endurance and muscular efficiency simultaneously. The length of the intervals, the quantity of repetitions, and the high degree of intensity are what define this kind of training. It differs from aerobic cardiovascular activities in that it primarily relies on the anaerobic energy system, although it does not completely exclude the use of aerobic pathways. Therefore, HIIT maximizes the utilization of the anaerobic energy releasing system.**(Tabata et al., 1996)**.

Football's physical requirements have gradually increased throughout time. Even though the total distance covered during games has remained largely constant, there are now a lot more high-intensity activities like sprints and fast runs. HIIT has been demonstrated to be a successful method for enhancing certain physiological factors crucial to sports performance in order to combat these increasing demands. These include enhanced anaerobic capacity, augmented oxygen uptake, and better cardiometabolic health (**Minano-Espin et al., 2017**). Against traditional training, HIIT has also performed better in terms of blood glucose control, flexibility enhancement, and enhancing anaerobic and neuromuscular performance (**Bauer et al., 2022**).

1.5 Effects of High Intensity Interval Training

Football players who exercise in HIIT protocols exhibit greater physical fitness and improved glucose metabolism. Research has shown that HIIT boosts overall athletic capacity but also results in significant reduction of body fat. Such improvements are higher than those achieved through longer, less demanding training schedules. Several studies involving individuals aged 18 to 45 have demonstrated that significant gains in cardiovascular health are shown with both HIIT and traditional endurance exercise. However, HIIT typically produces greater gains in VO2 max. It is an important key indicator for identifying the ability of aerobic strength. Among adolescents, HIIT programs lasting a month or more have led to significant boosts in cardiovascular fitness and moderate enhancements in body composition.

Moreover, HIIT has been found to improve vascular function and promote healthier blood vessel indicators more effectively than moderate-intensity continuous training.

While moderate-intensity exercise tends to result in larger decreases in body weight and resting heart rate, HIIT is more closely associated with substantial increases in VO2 max. Overall, HIIT brings about numerous physiological changes, offering a comprehensive boost to an athlete's performance and endurance. It involves alternating between periods of strenuous exercise and rest or low-intensity recovery. To improve cardiovascular health by increasing circulation and oxygen delivery to muscles and organs, increase the pumping function of heart and boost the heart rate. It also increases the metabolic rate, resulting in greater calorie burn during and after exercise, which can aid in weight loss and management. Regular HIIT sessions improve both aerobic and anaerobic endurance, enhancing stamina and performance. To increase muscle growth and strength by recruiting various muscle fibres, with a focus on fast-twitch muscle fibres. It helps maintain lean muscle mass and is quite effective at reducing body fat, particularly abdominal fat, which results in a more favourable body composition. HIIT can improve insulin sensitivity, which is advantageous for individuals with insulin resistance or type 2 diabetes. Because HIIT causes EPOC, the physique keeps burning more calories after exercise to repair tissues, restore oxygen levels, and refill energy stores. In addition, HIIT workouts save time because they are usually shorter than standard steady-state workouts.

1.6 Aerobic Training

Aerobic exercise enhances muscle function and fortifies the heart and lungs. The goal of aerobic training is to improve athletic results and training response. Any activity that causes a little increase in breathing difficulties and a rise in heart rate is considered an aerobic training exercise. The work we're doing needs to be consistent and ongoing. Walking, running, swimming, and using an elliptical machine were among the aerobic exercises. Aerobic activities typically involve sustained, continuous effort. Examples include sports like tennis, racquetball, squash, and various martial arts. In contrast, exercises such as weight training, which consist of short, intense bursts of activity, are not considered aerobic.

One kind of workout that works the body's major muscle groups is aerobic exercise. It is typically distinguished by its repeated and rhythmic structure. The intensity of an aerobic workout can be adjusted to control the level of effort exerted. This type of exercise elevates the heart rate and raises the amount of oxygen the body uses. The term aerobic itself signifies with oxygen. Breathing regulates how much oxygen reaches

muscles during aerobic exercise, which aids in energy burning and movement. Aerobic, also known as with oxygen, is a form of physical exercise aimed at improving cardiorespiratory endurance. For at least twenty minutes per session, this kind of exercise works the main muscular groups in the arms and legs through repetitive, rhythmic motions. Aerobic activities typically involve sustained, continuous effort. Examples include sports like tennis, racquetball, squash, and various martial arts. In contrast, exercises such as weight training, which consist of short, intense bursts of activity, are not considered aerobic. It involves aerobic movements that burn fat, exercises that build muscle, and stretching, all performed to music. College-level boys find aerobic dancing challenging as it provides a sense of performance while toning their bodies and strengthening their cardiovascular system. The use of music in aerobic dance has become increasingly popular as a motivational technique. Overall, aerobic dancing is vital for maintaining a healthy cardiovascular system. It is a long-lasting activity that does not cause oxygen debt in the muscles. Aerobic dance makes the heart and lungs work harder than they would at rest by overloading them. The word "aerobic" itself denotes the presence of oxygen or air. The amount of oxygen consumed during aerobic dancing is equal to the amount needed for the exercise (**R.Sridhar, 2017**).

1.7 Effect of Aerobic Training for Football Players

For football players, aerobic dance training proves highly effective. This specific exercise approach has a proven track record of enhancing various motor fitness parameters vital for the sport. For example, it significantly improves agility, increases body flexibility, and sharpens dribbling ability (**Margaret Hickey, 1994**). Furthermore, another study underscores the notable benefits of aerobic dance for footballers, confirming its positive impact on crucial motor skills such as agility, flexibility, and dribbling proficiency (**R. Sridhar, 2017**). This indicates that incorporating such training into an athlete's regimen can lead to substantial improvements in their overall performance on the field. It has been demonstrated that aerobic dancing on an air dissipation platform improves body composition, lowers oxidative stress levels, and increases cardiorespiratory fitness in older persons, especially those who are fat or overweight **(Moreira-Reis et al., 2022)**. Throughout time, aerobic dance has developed in order to minimize the occurrence of lower limb injuries, transforming it into a more secure workout option for athletes, thanks to progress in training methods and strategies for preventing injuries **(Ross, 2017)**. Aerobic dance, along with other forms of regular aerobic exercise, has the potential to

greatly improve cardiovascular endurance, heart and lung function, and overall physical fitness. This makes it an advantageous component to incorporate into the training routine of football players **(Subekti et al., 2023)**.

Aerobic dancing, a pleasurable exercise modality, holds promise for improving mental and physical strength. In recent times, the therapeutic benefits of aerobic dancing in promoting overall well-being have gained greater acknowledgment, alongside its appeal for aesthetic and recreational purposes **(Wang et al., 2023)**.Aerobic exercises enhance the cardiovascular system by elevating the need for oxygen for an extended duration. These activities aid in weight control by elevating glucose and fatty acids in the bloodstream, thereby reducing appetite. Consistently engaging in aerobic exercise can result in enhancements in lung capacity, heart functionality, and vascular well-being. Furthermore, aerobic exercises contribute to the enhancement of fitness, endurance, and overall physical performance.

1.8 Muscular Strength

In order to carry out daily actions like lifting, carrying, and moving articles, muscular power is necessary. Muscular strength is the maximum force that group of muscles can generate in a single effort. Muscular strength allows individuals to perform everyday physical tasks like lifting bags, opening large doors, or performing household chores, more efficiently and with less fatigue. In addition to maintaining a healthy weight and preventing injuries, strong muscles also promote proper posture. Regular strength exercise enhances physical resilience, endurance, and bone and muscle health. In addition to its physical advantages, it boosts self-esteem, creates a more favourable body image, and provides a feeling of accomplishment. Exercise becomes more interesting when one's strength increases because it may lead to new opportunities to try out different physical pursuits. Strength training increases bone density by applying regulated physical stress, which directly affects bone density.

This reduces the risk of conditions like osteoporosis. It also helps in weight management by increasing the metabolic rate, which allows the body to burn more calories even at rest. Resistance exercises performed on a regular basis increase joint stability and lower the chance of being hurt, especially in the elderly. Gaining lean muscle mass improves coordination and balance, which lowers the risk of falls and maintains independence as people age. In addition to its physical benefits, resistance training helps

alleviate the symptoms of chronic illnesses. It has demonstrated efficacy in the treatment of illnesses like depression, diabetes, obesity, cardiovascular disease, low back pain, and arthritis. Additionally, new studies indicate that strength and aerobic training together can enhance cognitive function, particularly in older persons. Together, these factors help people of all ages achieve greater physical and mental wellbeing as well as a higher standard of living.

1.9 Muscular Endurance

Muscular endurance is the strength of muscles to continue working against a resistance. It is a precious quality that allows the muscles to continue to work in spite of opposition, which could either come from external weights or even the body weight of the individual. Essentially, it is the duration for which such muscles can maintain their activity without getting exhausted. Stronger these muscles make them able to contract and resist these forces over time. improve support and stability for long periods of time. Improve cardiovascular endurance in muscles. Improve the ability to do everyday activities, such as lifting heavy loads, efficiently. improving sports performance for endurance sports.

Muscular endurance of strength training is the capacity to perform multiple repetitions of an exercise without necessarily having to rest to recover. It can be observed in the movement of performing a sit-up, full squat or biceps curl using a weightiness that is considered light to moderate while still maintaining proper form. Observe that muscular endurance is muscle-specific to the muscle being targeted while performing the exercise. Sprinting, jumping, tackling, and rapid direction changes are some of the common bursts of high-intensity activities associated with football games.

Good muscular endurance is required by the players to handle the demands so that they can stay active throughout the game without premature fatigue. Fatigue causes a compromise in technique and posture, which increases the likelihood of injuries such as muscle strains, ligament injuries, or joint issues. Sufficient muscular endurance maintains optimal movement mechanics, reducing risk of injury typically caused by fatigable errors. Highly endurance players are able to maintain performance over the whole duration of a match.

This consistency enables them to act effectively, preserve decision-making and play strategically without their performance being recognizable in a decline. Playing positions have differing demands on endurance. Midfielders cover the most distance and

usually vary their pace, necessitating cardiovascular and muscular endurance. Defenders need stamina to stay in their lines and react immediately to danger. Forwards depend on endurance in order to maintain attacking momentum and apply pressure to the opposition effectively. All positions on the field serve to highlight the necessity for certain endurance in order to meet specific physical and tactical requirements.

1.10 Speed

Speed is the ratio of the distance covered to the time required to complete that distance in sports like running and swimming. It is typically associated with moving in a straight line. However, for players in sports like touch, netball, or water polo, speed can also encompass the ability to change direction while in motion. It is the capacity to complete any movement in the shortest amount of time. Being able to move fast is conditional. It involves the central nervous system. It is one of the components of fitness. The capacity to move quickly is greatly influenced by fibers, and coordination and genetics also play a role.

Improving coordination and techniques can only enhance speed ability to a certain extent, as it primarily relies on the quantity of fast-fibres within an individual's body. However, it is important to note that speed ability cannot be significantly improved beyond a range of 20% to 25% through training alone. Speed, defined as the capacity to complete motor activities in the least amount of time, plays a different role depending on the sport. In football, it is crucial for both attacking and defending. Fast players can breach defensive lines, outrun opponents during counterattacks, and generate scoring chances. On the defensive side, speed helps players close down attackers, recover lost ground, and intercept passes at the right moment. A defender with good speed can quickly get back into position, reducing the opponent's chances of scoring.

The ability to accelerate or reach full speed fast, is particularly crucial in football. It helps players find open spaces, beat opponents in one-on-one situations, and shift direction without delay. In high-pressure situations, this sharp acceleration can make a difference in gaining an advantage or preventing a threat. The modern game relies heavily on a fast tempo and high pressing tactics. Players must apply pressure quickly, cut off passing options, and sustain this intensity throughout the match, all while managing fatigue effectively. Football games involve frequent shifts between attacking and defending. Players who possess speed can swiftly switch between defensive and offensive roles, ensuring that the team maintains its tactical flexibility and ability to react promptly.

1.11 Power

Power in athletes is determined by the speed at which they can produce their maximum strength. Enhancing power output can be achieved through training at moderate levels of velocity and force. Power is characterized by the capacity to generate high levels of muscular force rapidly. It is comprised of two key elements: strength and speed. The energy required for activities such as throwing, jumping, weightlifting, and diving in track and field is primarily derived from high-energy phosphate compounds. Short-duration events lasting around 10 seconds, such as a 100-meter sprint, rely on anaerobic glycolysis to produce ATP for energy. As the event's duration lengthens and its intensity declines, anaerobic glycolysis becomes more efficient in providing energy. Events lasting at least 60 seconds start to involve aerobic metabolism of carbohydrates and fats for energy production. In longer events lasting minutes to hours, aerobic metabolism plays a more significant role in energy contribution.

Football demands short bursts of explosive actions such as sprinting, jumping, sharp directional shifts, and strong tackles. To carry out these moves effectively, players need power, which combines strength and speed. This physical quality helps in the generation of the power and speed required to play at the elite level in a game. Power is especially important in aerial combat, where players fight for headers or attempt to jump over one another. Players who possess greater power are able to jump higher, gain possession of the ball in the air, and establish control in these physical contests. The ability to hit the ball forcefully is also a most critical characteristic of power in football. Stronger players are able to shoot more quickly and pass more precisely, helping their team attack. Besides technical skill, power also makes a player more physically present on the field. Strong players can cover up the ball better, resist pressures, and win physical battles, which is a factor in their effectiveness at retaining possession and setting the tempo for the game. A high power-to-weight ratio is also beneficial for mobility. It allows players to reach their maximum speed, boost the speed and rebound quickly for repeated sprints.

1.12 Agility

Agility is the capacity to change course, start or stop movement abruptly, and alter body position under control. It is dependent on balance, strength, coordination, and overall skill. To improve agility, athletes need to build a foundation of physical fitness relative to their training level. This quality is the essence of most sports and involves a blend of

speed, balance, reactions, and muscle control. Football agility allows players to evade their competitors, create room to manoeuvre, and rapidly turn while dribbling, defending, or ball-running. Agility allows players to respond quickly to sudden situations such as rebounds, deflections, or sudden defensive opportunities. Improved agility sharpens reaction time and decision-making abilities. Footballers are often required to respond quickly out of highly changing situations. Agility exercises facilitate coordination between lower and upper body, improve footwork, and improve body stability. The improved coordination is helpful in advanced ball skills, pressure control, and change of movement, all of which are essential within a high-speed game.

1.13 Cardiovascular Endurance

Cardiovascular endurance or aerobic fitness describes the body‘s capacity to sustain long-term physical exertion. It primarily checks how well the heart and lungs work together to supply an adequate amount of oxygen to contracting muscles when an individual is continuously engaged for an extended period. Such efficiency is critical in maintaining performance and stamina for a long duration. It allows sportsmen to sustain moderate efforts for a longer duration and even withstand savage bursts before exhaustion. Improved cardiovascular endurance increases blood flow, and thus more oxygen will be provided to muscle cells. This oxygen assists in fuelling the body's energy output. Football matches take approximately 90 minutes, and competitive games may extend into extra time or penalty shootouts.

Good cardiovascular fitness is demanded of players to remain active and concentrated for this duration. It helps them to maintain performance levels and avoid undue fatigue. Football consists of a great deal of high-intensity movements, e.g., running, tackling, and direction change. Effective endurance allows the players to recover quickly amidst such efforts, limiting the impact of fatigue and maintaining quality performance. Modern football utilizes high-press tactics, where sustained pressure is applied in a bid to win the ball back. Sustained effort is necessary in this approach, which can be maintained only by athletes blessed with good aerobic capacity. Players with strong cardiovascular systems may press for the entire game, throw off the opposition's rhythm, and create scoring opportunities through forced mistakes. Athletes that are aerobically fit can also recuperate from games more quickly, experience less muscle soreness, and adapt to the next game more quickly.

1.14 Heart Rate

The body's circulatory system plays an important role in moving blood through entire body. Its primary functions include delivering essential oxygen and vital nutrients to cells, while also removing waste products. With each beat, the heart pumps blood, sending oxygenated blood to muscles or directing deoxygenated blood to the lungs for a fresh supply of oxygen. The heart's workload directly relates to the heart rate, that measures how many heart beats occur in a minute. A person's resting heart rate is determined after their body has been motionless for at least five minutes, usually while they are lying down in a quiet place. A healthy resting heart rate usually falls between 60 and 100 beats per minute (bpm). If the resting heart rate is higher than 100 beats per minute, the heart might be exerting too much effort to pump blood. This high rate may signal a dangerous condition and requires the services of a doctor immediately. At the other extreme, heart rates at or below 60 bpm are not unusual in endurance-trained athletes, whose bodies utilize blood oxygen very efficiently. The parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS), two parts of the involuntary nervous system, control heart rate.

The SNS releases hormones known as catecholamines, i.e., norepinephrine and adrenaline, that upsurge heart rate. However, the PNS releases acetylcholine, that is responsible for slowing down the heart rate. Several reasons such as stress, caffeine intake and enthusiasm can upsurge heart rate briefly. But certain interventions like walking meditation or slow, deep breathing can lower it. During any exercise of whatever duration, heart rate typically increases and maintains itself at a higher level throughout the activity. Exercise suppresses the PNS to allow the heart rate to build up gradually. Exercise that is more intense activates the SNS, which further raises the heart rate. Regular, sustained endurance exercise reduces an individual's resting heart rate gradually. It is achieved through enlargement of the heart, increased contractile strength of the heart, and an increased time for blood to fill the heart chambers. Decrease in heart rate is achieved through heightened activity of the PNS, accompanied by reduced sympathetic nerve activity.

1.15 VO2 Max

In sports and exercise science, VO2 max is often used by experts to assess cardiovascular fitness of an individual. The test determines aerobic fitness by determining

the highest rate at which the body consumes oxygen for aerobic exercise. These tests typically involve jogging on a bicycle ergometer or treadmill. VO2 max, is the uppermost level of oxygen one can ingest and utilize during physical activity at high intensities or most effort. It is much like an automobile engine: as a bigger engine can burn more fuel in an effort to generate more power, having more VO2 max allows the body to utilize more energy and, as such, possess greater aerobic ability. When there is hard physical exercise, the muscles require increased oxygen supply. Therefore, an exercise will be easier if the body uses and utilizes more oxygen. The unit of measurement of VO2 max is $ml \cdot kg^{-1} \cdot min^{-1}$.

For football players, this measurement is highly significant. It is the highest amount of oxygen that an athlete can effectively use while engaging in strenuous activities on the field, having a direct impact on their stamina and performance as well. In football, as the game involves dynamic movement and not stationary effort, with sprint bursts and intense play, this parameter decides the aerobic capacity of the player. With high VO2 max, the athletes are able to maintain their performance level without unwanted fatigue, especially during the demanding phase of the match. It also allows players to recover faster during brief interruptions, to sustain effort and reduce dips in performance over time. Since the game is also punctuated with high and moderate intensity, players with a strong aerobic system are able to manage repeated sprinting, change of direction quickly, and explosive movements more effectively. The physical demands vary for playing positions. Midfielders cover greater distance with repeated speed changes, and defenders need to stay awake and respond to threats through timely movement. All roles are supported by high VO2 max through meeting their individual physiological demands.

Training regimens that target VO2 max development optimize the body in oxygen delivery and utilization, leading to enhanced endurance, increased capillary density, and muscle energy production. Enhanced aerobic capacity also delays the onset of fatigue, allowing players to be physically steady and mentally sharp, which is crucial in making decisions and performing during the late match. Furthermore, well-developed aerobic fitness can enhance superior biomechanics, reduce muscle fatigue, and reduce the risk of injury. Hence, VO2 max is a critical indicator of endurance, fast recovery, efficient sprinting, and overall hardness throughout a football match.

1.16 Passing

Passing in football stands as a fundamental technical ability, essentially shaping the flow and effectiveness of play. It is far more nuanced than simply transferring the ball from one player to another. Rather, passing requires players to assess the field, identify open teammates, and select the optimal option under pressure. Executing a successful pass also demands precision and the correct amount of force, as both under- and over-hitting can disrupt possession or squander attacking opportunities. A well-delivered pass helps players bypass pressing opponents and maintain control of the game. Whether it is a quick give-and-go or a long diagonal switch, accurate passing allows teams to break defensive structures and build attacks from deeper areas. The inside-push pass is a commonly used technique that use the inside of the foot to strike the centre of the ball, while the non-kicking foot points toward the target for direction and balance. The success of this pass depends on both accuracy and the force applied.

Accurate passing relies on proper technique, whether using the outside, inside or laces of the foot, depending on distance and tactical need. Short passes help in close-range exchanges, while long passes or switches open up the play by shifting the ball across the field. Goal-scoring opportunities are created when through balls are sent into the gap behind defenders for forwards to run onto. Crosses are essential for shattering compact defences since they are typically given from wide positions and are intended to locate teammates in the box. Players can move quickly with one-two passes, avoiding markers and making progress. Chipped passes, which are useful in crowded areas or to build up aerial attacks, are lofted with backspin to lift the ball above defenders. Gaining proficiency with these passing styles improves tactical versatility and team fluidity.

1.17 Kicking

Kicking in football is kicking the ball with the foot, and it is vital for a lot of situations - scoring, clearing, passing, and set-pieces. It is one of the most basic and technically challenging skills. Players acquire the skill at an early age, and the highest change is usually noticed from four to ten years. Semi-professional players are more accurate, as they constantly practice and do not have a lot of technique variability. Different kicks serve different purposes. The instep kick, or laces kick, is employed to build power, usually for long shots and passes. The inside-of-the-foot technique provides control for short, accurate passes. The outside-of-the-foot kick provides uncertainty,

employed to bend the ball around a defender or into a specific location. Chipped or dinked kicks gradually propel the ball over and beyond a defender or goalie, utilizing soft touch and precise control. Curling kicks employ spin by the inside or outside of the foot, which is useful for set-pieces or when shooting for the top corner of the goal. All forms of kicking possess unique tactical advantage and assist in making a player more efficient on the ground.

1.18 Dribbling

Dribbling is the art of maintaining and manoeuvring the ball without losing possession to defenders. Close ball control, quick footwork, and sharp spatial sense are required. Dribbling is employed to hold on to possession, beat defenders, and create space to pass or shoot. Effective dribbling involves light touches on both feet, allowing players to speed up or alter direction at their own will. Using the body to shield the ball adds an extra security against opposition. Several techniques make up increased dribbling. Regulated turns are aided by the inside foot, as the outside foot is often used to push the ball forward at speed. Skill moves, such as step-overs or drag-backs, add deception. A step-over tricks defenders by feigning movement, while a drag-back uses the inner foot to pull the ball behind the standing leg, allowing a quick turn away from a challenge. Strong dribblers combine technical skill with creativity and quick thinking, often becoming game-changers by drawing fouls, opening up play, and energizing the team's attack.

1.19 Shooting

Striking the ball toward the goal with the foot or head in an attempt to score is known as shooting. A shot on target either results in a goal or forces the goalkeeper or defender to intervene. Various shooting techniques exist based on the desired outcome. The straight shot involves hitting the ball with the laces, keeping the ankle firm, to generate power and direction. The instep drive and the Swiz shot use the laces and the inner or outer foot to combine power with spin. The inside-foot shot involves turning the hip outward to strike the ball cleanly for better placement and curve. Each technique offers advantages based on the situation—whether the player is under pressure, at a distance, or aiming to bend the ball around a wall or goalkeeper. Accurate shooting is not only about power but also timing, angle, and composure under pressure. Players who master these techniques can consistently threaten the opposition‘s goal and influence the outcome of a match

Furthermore, an outside foot shot, also known as a trivial, can be executed by striking the ball with the outside three toes of the foot. This technique produces a curve effect on the ball. Ricardo Quaresma, a notable player, has frequently utilized this type of shot in various game situations. Lastly, a header involves using the head to strike the ball. This technique is employed when the ball is too high to be controlled effectively with the feet or chest. Body positioning is a critical element in shooting technique. It is essential for a player to place their non-kicking foot next to the ball, lean back slightly, and maintain focus on the target, typically the goal. There are various types of shots in soccer. Power Shot is applied to make the most of power and speed, typically for outside-the-box shots or to batter goalkeepers with sheer force. Finesse Shot, alternatively, gives greater emphasis to finesse and accuracy, typically to kick the ball to the goal corners, pass it around the goalkeeper, or for curved passes. The Chip/Dink is a gentle shot used to chip the ball over the goalkeeper, most often one-on-one or when the goalkeeper has wandered out of position. The Volley requires perfect timing and technique, as players strike the ball in the air, so that it comes down in a classic fashion, and very often into the net.

Players move back a few steps and establish their momentum before striking the ball. The size and direction of these steps may vary depending on the specific shooting position. The point of contact on the foot varies with the type of shot being taken. While taking power shots, players tend to use the laces (instep) of the boot. Finesse shots or chips may include hitting with the inside or outside of the foot. Proper follow-through helps to make a successful strike. This involves fully extending the kicking leg upon impact of the ball, so as to generate power as well as accuracy. Goal-scoring in football combines technical skill, strategic decision-making, knowledge of goalkeepers, and regular exercise to allow for one to consistently make a contribution towards the achievement of a team.

1.20 Statement of the Problem

To assess the Effect of High Intensity Interval Training, Aerobic Training and Concurrent Training on Selected Physical, Physiological and Skill Performance Variables among Football Players.

1.21 Objectives of the Study

- ✓ To find out the effect of High-Intensity Interval Training (HIIT).
- ✓ To evaluate the effect of Aerobic Training.

- ✓ To investigate the effect of Concurrent High-Intensity Interval Training and Aerobic Training.
- ✓ To compare the effectiveness of High-Intensity Interval Training, Aerobic Training, and Concurrent Training.
- ✓ To identify which training method produces the most significant improvement in overall performance among intercollegiate male football players.

1.22 Hypothesis

1. The experimental groups showed significant improvements in selected physical variables compared to the control group.
2. The experimental groups exhibited significant enhancements in selected physiological variables compared to the control group.
3. The experimental groups displayed significant improvements in selected skill performance variables compared to the control group.
4. Concurrent training was more effective than High-Intensity Interval Training and Aerobic Training in improving overall physical fitness, physiological, and skill performance variables among intercollegiate male football players.
5. There were significant improvements in physical fitness, physiological, and skill performance variables among intercollegiate male football players who underwent High-Intensity Interval Training, Aerobic Training, and Concurrent Training.

1.23 Significance of the Study

1. The aim of this research is to help intercollegiate football players perform better on the field overall by enhancing their physical, physiological, and skill performance.
2. It will provide coaches with evidence-based insights on combining HIIT and aerobic training for optimal player development.
3. This study fills a research gap by examining the impact of HIIT and aerobic training on football players, providing useful contributions.
4. By improving physical conditioning and skill performance, the study may lead to better health outcomes and injury prevention for football players.

5. This research will help practical guidelines to football coaches and fitness trainers to design effective training programs concurrent HIIT and Aerobic training to optimize the physical and physiological development of players.

1.24 Delimitations

The study focused on intercollegiate male football players.

- ✓ The individuals' ages ranged from 18 to 21 years.
- ✓ The trial focuses on high-intensity interval and aerobic training.
- ✓ Independent factors were identified for skill, physical and physiological performance metrics.

1.25 Limitations

This study is limited to the following

- ✓ Rational habits were not to be considered.
- ✓ Natural of work was not to be considered.
- ✓ Life style were daily routine work was not to be considered.
- ✓ Daily health and food was not to be considered.
- ✓ The study's shortcomings include uncontrollable factors such as inheritance and environment.

1.26 Definition of the terms

1.26.1 Training

Training is a structured procedure designed to enhance individuals' knowledge, skills, and competencies to achieve specific objectives. It involves systematic methods for imparting technical expertise, improving efficiency, and ensuring proficiency in job-related tasks.

(Armstrong, M. (2021).

1.26.2 Sports Training

Sports training is a systematic and progressive process aimed at enhancing an athlete's physical, technical, tactical, and psychological capabilities to achieve peak

performance. It involves scientifically designed methods and techniques to improve various performance-related factors.

Bompa, T. O., &Haff, G. G. (2018).

1.26.3 High-Intensity Interval Training

VO2 max is the outcome of repeated, relatively short bursts of intermittent exercise, often done at or close to "all-out" exertion.

Gibala and Mcgee., 2008

1.26.4 Aerobic Training

Aerobic refers to activities that involve oxygen consumption to generate energy through aerobic metabolism, supporting sustained physical effort and endurance.

Wilmore, J. H., &Costill, D. L. (2004)

1.26.5 Muscular Strength

Muscular strength refers to a person's ability to move and lift objects efficiently. This important physical attribute is typically assessed by determining the maximum force a person can generate or the heaviest weight they can lift. These assessments are usually performed over a brief period, highlighting the capacity of a body to exert power for brief explosions.

Emily Cronkleton., 2019

1.26.6 Muscular Endurance

Muscular endurance describes the ability to perform repetitive actions compared to some form of resistance. It signifies the power to keep up an effort for a longer period, reducing tiredness and allowing for quicker recovery between bursts of activity. Essentially, it is about how long muscles can work without significant fatigue.

Ajmer Singh et al., 2003

1.26.7 Speed

Speed is the capacity to complete a movement in a brief amount of time

Matte M., 2011

1.26.8 Power

The neuromuscular system's power is its capacity to produce the greatest amount of force in the shortest amount of time. The duration of force application depends on the resistance or load an athlete must overcome.

Bompa, T. O., &Haff, G. G. (2009).

1.26.9 Agility

Explosive power is the capacity to generate force rapidly, overcoming resistance with high speed. It is a key component of dynamic strength, expressed in powerful motor movements.

Komi, P. V. (2003).

1.26.10 Cardiovascular Endurance

The capacity to maintain persistent physical activity for extended periods of time—from minutes to hours or even days—is known as endurance. It demonstrates how effectively the circulatory and respiratory systems provide oxygen to working muscles, enabling sustained effort.

Kenney, W. L., Wilmore, J. H., &Costill, D. L. (2019).

1.26.11 Heart Rate

The resting heart rate, which is a measure of cardiovascular efficiency and overall heart health, is the number of heart beats per minute when the body is at rest.

Citation: McArdle, W. D., Katch, F. I., &Katch, V. L. (2015).

1.26.12 Vo2 Max

The maximal oxygen consumption is at which the oxygen consumption reaches a plateau and either does not rise at all or increases only marginally with an additional labour load.

William.DMcArde., 2006

1.26.13 Passing

The act of passing the ball from one player to another on the ground or in the air, to a teammate who is in a better position is known as passing. The transfer of the ball to a team mate who is less likely than others to keep it because of a marker.

Mal, Biru, et al., 2005

1.26.14 Kicking

Kicking In association football (soccer), kicking is the primary method for players to move the ball across the field and attempt to score goals. The skill encompasses various

techniques, such as the instep drive, chip, and volley, each suited to different in-game situations.

Reilly & Williams (2022)

1.26.15 Dribbling

In football, dribbling is the ability of a player to maneuver the ball through defenders using skillful footwork, maintaining control while advancing across the field. This technique enables players to create scoring opportunities, bypass defenders and strategically position themselves for passes or shots. Effective dribbling requires a combination of agility, ball control, and spatial awareness.

Hughes, M., & Franks, I. M. (2004).

1.26.16 Shooting

In association football (soccer), shooting **is** the act of propelling the ball toward the enemy's goal with the primary objective of scoring. This action is typically executed using the feet but can also involve other parts of the body, such as the head, depending on the situation.

(Ali & Williams, 2021).

1.27 Research Gap

- HIIT and aerobic training have individually been studied, there is a lack of research that compares the isolated and combined (concurrent) effects of these training methods on the overall performance (physical, physiological, and skill variables) of football players in a single, controlled study.

- Most existing studies focus primarily on fitness outcomes, often neglecting sport-specific skill variables such as dribbling, passing, and shooting - which are crucial for football success. The effect of different training methods on these technical skills remains underexplored.